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The Canon of Polykleitos

RICHARD TOBIN

Abstract

The present study is an attempt to reconstruct the *Canon* of Polykleitos within the framework of the philosophical and practical principles of geometry available in Polykleitos's own time and to demonstrate the correspondence of this reconstruction to the Naples Doryphoros.

It is proposed that Polykleitos chose a specific member of the human body, the distal phalange of the little finger, as a basic module for his system, and after establishing a length and width for it based on his observation of nature, he used it as a point of departure for determining all the proportions of the human figure. By applying the most basic concepts of Greek geometry—ratio, proportion, *symmetria*—he developed a system which used a geometric mean in continuous progression.

The sculptor's simple, practical procedure required no mathematical calculation. It could have been completed in a short time using only a piece of cord with knots tied in it. The ancient literary sources on the *Canon* reveal only a vague knowledge of its system and fail to appreciate its thoroughly geometric character.

Despite the many advances made by modern scholars[1] toward a clearer comprehension of the theoretical basis of the Canon of Polykleitos, the results of these studies show an absence of any general agreement upon the practical application of that Canon in works of art. An observation on the subject by Rhys Carpenter remains valid: "Yet it must rank as one of the curiosities of our archaeological scholarship that no one has thus far succeeded in extracting the recipe of the written canon from its visible embodiment, and compiling the commensurable numbers which we know that it incorporates."[2]

Some scholars[3] have suggested that the Canon was influenced by Pythagorean mathematics, which considered numbers as geometric entities, having spatial identity. If this is in fact the case, it would be logical to look for a geometric rather than linear basis for the Canon. The present study proposes such an areal approach[4] for a solution to the metrical system of Polykleitos, one which reflected the current Greek number theory and geometric practice.[5]

A POSSIBLE SOLUTION: THE AREAL CANON

The starting point of my proposal is that the Polykleitan Canon was generated from the dimensions of the third or *distal phalange* of the little finger. Having determined "from nature" its length and width (side view, ill. 1), Polykleitos conceives of it as a spatial number, in this instance a rectangle. He proceeds to apply a square to that number (whose side is equal to the number's long side; i.e. the phalange length). The diagonal of that new square number becomes the length of the next spatial number, the *middle phalange*. This number is in turn "squared," and its diagonal becomes the length of the next number, the first or long phalange of the little finger. The ratio[6] between the first digit/phalange and the second is the same as the ratio between the second phalange and the third. Thus he has established a true proportion[7] by means of a constant ratio. This ratio is approximately 1:1.4142 (the side of a square to its diagonal), though its arithmetic value was not required nor was it employed for a process carried out with a string or cord.[8]

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[1] H. Diels, *Antike Technik* (Leipzig 1914) 14f; C. Antí, "Monumenti Policletei," *MonAnt* 26 (1920) col. 691-704; R. Bianchi Bandinelli, *Policleto* (Florence 1938); S. Ferri, "Nuovi contributi esegetici al 'Canone' della scultura greca," *RivIstArch* (1940) 133ff; L. Stefanini, "Inspirazione pitagorica del Canone di Policleto," *Giornale critico della filosofia italiana* (1949) 28.2.III, 554-60; J.E. Raven, "Polyclitus and Pythagoreanism," *CQ* (1951) 147-52; D. Schulz, "Zum Kanon Polyklets," *Hermes* 83 (1955) 200-20; P.E. Arias, Policleto (1964); Th. Lorenz, *Polyklet* (Wiesbaden 1972); H. Von Steuben, Polyklet (Tübingen 1973).

[2] Rhys Carpenter, *Greek Sculpture* (Chicago 1960) 100.

[3] See bibliography (supra n. 1).

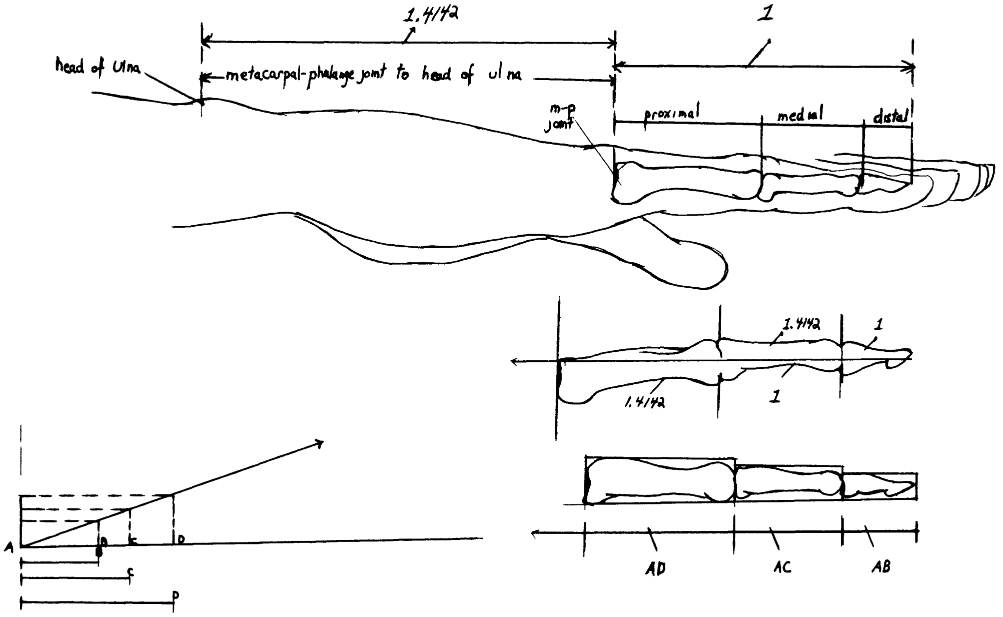
[4] An invaluable resource for this interpretation of the Canon is Euclid's Elements: Euclides, *Elementa, I-XII* (Leipzig 1883-1888), Bibliotheca Teubneriana, ed. Heiberg and Menge, vols. 1-4; *The Thirteen Books of Euclid's Elements* (New York 1956), a republication of the Cambridge second edition (1926) with introduction and commentary by T. Heath; translated from the Heiberg text.

[5] The Greek mathematical tradition can be found in Euclid's *Elements* (supra n. 4). The sections of his work applicable for this study are largely indebted to Pythagorean geometry: ". . . we may say that the Pythagorean geometry covered the bulk of the subject-matter of Books I, II, IV and VI of Euclid's *Elements.* The case is less clear with regard to Book III . . . but . . . we conclude that they too were part of the Pythagorean geometry." (T. Heath, "Mathematics and Astronomy," in *The Legacy of Greece*, Oxford 1941, 112f). These sections deal with the two major methods of algebraic geometry—the application or transformation of areas and proportion—as well as number theory and the use of the gnomon. See Heath's commentary (supra n. 4): application of areas, Vol. 1, 36, 343ff, 351ff, 370ff, 384, 403; Vol. 2, 187, 258-60; proportion: Vol. 2, 112ff, 131, 292-93; the gnomon: Vol. 1, 351ff, 370ff; number theory: Vol. 1, 188ff, 372ff, Vol. 2, 292-93. A fuller treatment of Pythagorean geometry in Euclid can be found in Heath's *A History of Greek Mathematics* (Vol. 1: Thales to Euclid, Oxford 1921) and in his *A Manual of Greek Mathematics* (Oxford 1931).

The Pythagorean geometry incorporated into Euclid's *Elements* provides a fairly clear idea of the concepts that may have figured prominently in the Polykleitan number theory. The concepts that are most open to later misinterpretation are those of symmetry, proportion, and harmony. *Symmetry* begins with a rational or measurable unit; when provided with another unit to which it can be compared or measured, we have a *ratio*, a relation or expression of comparison or mensuration. When that ratio extends to more than two units, applying to at least three terms, we are dealing with a *proportion*, a series of at least three terms linked by a constant (unchanging) ratio. We thus have a state of commensuration, or *symmetry*. It would appear that harmony is simply an equivalent concept for symmetry viewed on the aesthetic level (see n. 22).

This extremely practical procedure, carried out without dependence upon any mathematical calculation, evolved in a manner in keeping with Galen's description of the Canon:[9] (ill. 2)

1. Third to middle phalange, middle to first (ill. 2, i-iii);
2. All the phalanges—i.e. the entire length of the



ILL. 1

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[6] Ratio, or λόγος: *λόγος ἐστὶ δύο μεγεθῶν ὁμογενῶν ἡ κατὰ πηλικότητα ποιὰ σχέσις.* Bk. V, def. 3. "A ratio is a sort of relation in respect of size between two magnitudes of the same kind." (See Heath, Vol. 2, 114, 116-19, supra n. 4). It is important to note here the precise meaning attached to ratio (λόγος) and proportion (*ἀναλογία*) in the Greek mathematical tradition. The frequent misuse and confusion of the two terms, as early as Vitruvius (*De arch.* III. 1. 65), has led the attention of proportional studies away from the true geometric character proper to any metrical system based upon Greek mathematics (see n. 7, proportion).

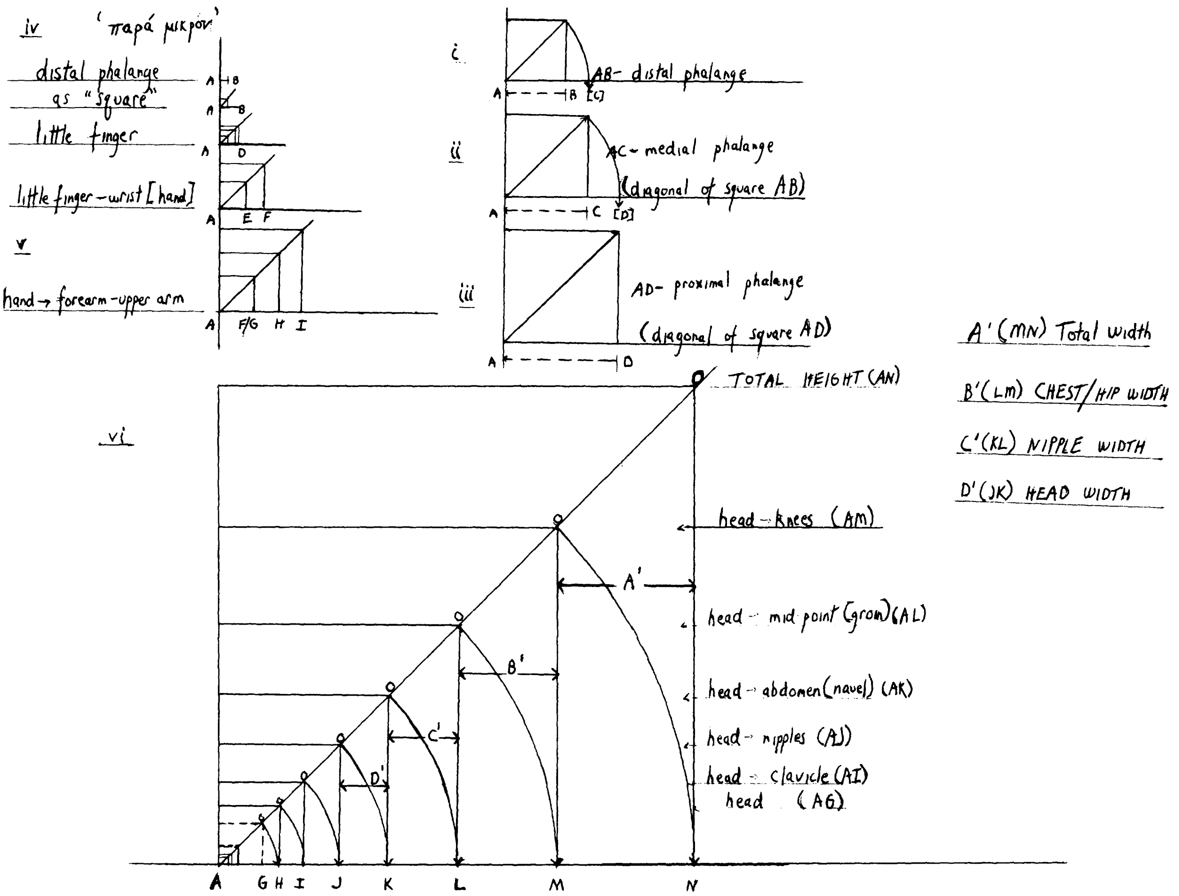
[7] Proportion: *τὰ δὲ τὸν αὐτὸν ἔχοντα λόγον μεγέθη ἀνάλογον καλείσθω.* Bk. V. def. 6. "Let magnitudes which have the same ratio be called proportional" (see Heath, Vol. 2, 114, 129ff, supra n. 6 and n. 4). For Euclid and the Greek mathematical tradition, "a proportion in three terms is the least possible" (*Elements* Bk. V, def. 8). It should not be confused with a ratio, involving two magnitudes. Modern usage tends to substitute "proportion" for a comparison involving two magnitudes (i.e. length and width), and hence mistakes a mere grouping of simple ratios for a complete proportion system, often with a linear basis at odds with the areal approach of Greek geometry.

[8] As a practising sculptor I found the process most helpful in my own work; in applying the identical procedure to a wax figure over ten feet high—altering the initial spatial number to suit my own intentions—I was able to establish the entire proportional system for the figure within a quarter of an hour.

[9] Galen. de plac. Hipp. et Plat. 5, 3 [162] (p. 449 Kühn; p. 425 Müll.):

> *τὸ δὲ κάλλος οὐκ ἐν τῇ τῶν στοιχείων, ἀλλ' ἐν τῇ τῶν μορίων συμμετρίᾳ συνίστασθαι νομίζει* (Χρύσιππος), *δακτύλου πρὸς δάκτυλον δηλονότι καὶ συμπάντων αὐτῶν πρός τε μετακάρπιον καὶ καρπόν, καὶ τούτων πρὸς πῆχυν, καὶ πήχεως πρὸς βραχίονα, καὶ πάντων πρὸς πάντα, καθάπερ ἐν τῷ Πολυκλείτου κανόνι γέγραπται. πάσας γὰρ ἐκδιδάξας ἡμᾶς ἐν ἐκείνῳ τῷ συγγράμματι τὰς συμμετρίας τοῦ σώματος ὁ Πολύκλειτος* (Galen, *De plac. Hipp. et Plat.* 5).

Author's translation: "Chrysippos holds beauty to consist, not



Ill. 2

little finger—relate to the palm-wrist (1:1.4142); the length of the finger is squared, its diagonal is taken, and that new diagonal becomes the length of the spatial number that embodies the length and width of the metacarpal and carpal, i.e., from the knuckle or origin of the little finger to the head of the ulna (ill. 2, iv);

3. The entire hand length—the little finger, palm and wrist—is squared to produce the length of the forearm (to the olecranon process of the ulna (ill. 2, v);
4. The forearm is in turn in the same ratio to the upper arm, which terminates at the top of the shoulder, on the acromium (ill. 2, v);
5. *καὶ πάντων πρὸς πάντα*: the length of the upper arm (from the elbow to the acromium) is shifted over to the body proper, where it is established as the length from the top of the head to the juncture of the clavicles (at the manubrium of the sternum, on the same line with the acromium): The squaring process continues on the body proper (ill. 2, vi):

- the diagonal of this head-to-clavicle "square" extends from the top of the head to the nipples;
- the squaring of this new length (head-to-nipples) yields a diagonal whose length extends from the head to the abdomen, above the navel and on a line with the elbow;

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in the commensurability of elements, but in the commensurability of the parts/members (of the body): that is to say, in the commensurability of finger to finger, and of all these fingers with the metacarpal and carpal; and of these with the ulna (forearm), and of the ulna with the upper arm; and of all these with the whole, as it is set forth in the Canon of Polykleitos."

While it appears that Galen is referring in this use of dactyl (δάκτυλος) to the relation of one finger to another, I believe the original Polykleitan sense would have reference to the relation between the phalanges of each finger. I would suggest a tendency in Greek anatomical usage to designate the entire member by a term that applies literally to the part or parts that compose it. In any case it is unlikely that Galen was aware of the practical application of the procedure he describes.

- the head-to-abdomen length is squared, yielding a diagonal whose length extends to the groin, the mid-point of the body;
- this new length (head-to-groin) yields a diagonal that extends from the head to the kneecaps;
- the head-to-kneecap length is squared, that diagonal extends to the bottom of the feet, or the base of the figure.

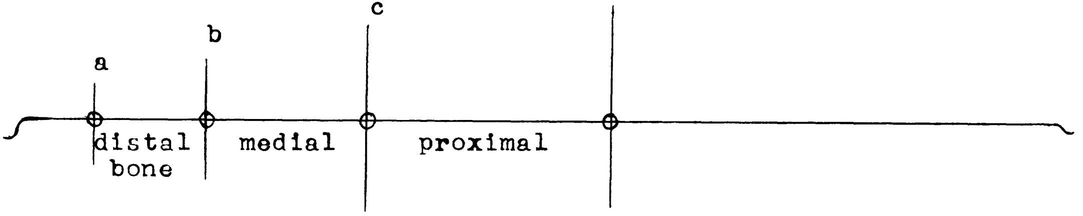
Polykleitos evolved the entire figure in this manner. He employed a module that was unique at the same time as multiple: a geometric unit generating a series of proportions based on one constant ratio. That ratio was the length of each spatial number with the diagonal of its square, or 1:1.4142. That series of proportions involved the generating of the areal dimensions (length and width) of each successive part of the body, each conceived as a geometric number. These numbers evolved through a geometric progression, beginning with the initial unit of the distal phalange.

Polykleitos worked with an areal module; he set up the length and width of the distal phalange of the little finger, as he found it to exist most perfectly "in nature." Once that module was placed in the progression, the new length of each successive part of the body yielded its corresponding width, making the new number commensurable with the preceding numbers and ultimately with the generating number of the distal phalange. Thus this gnomon-like growth produced a series of geometrical forms related to one another in size and "identical" in shape. In effect, the entire chain of geometric shapes possessed the same form.

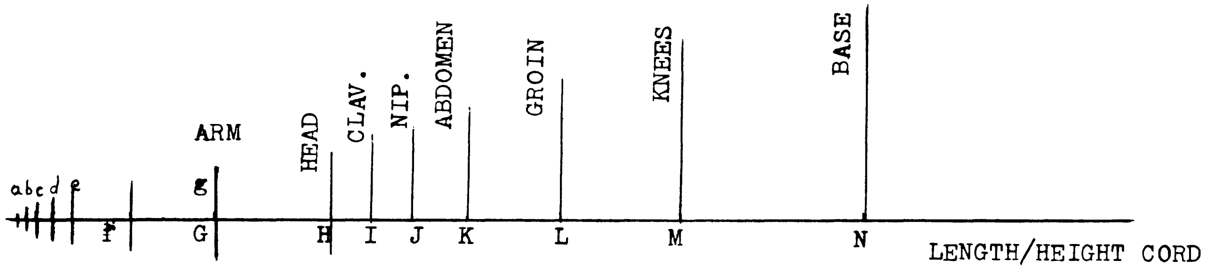
The practical application of this system probably involved a procedure similar to the following (ill. 3). Though the use of this system yields the successive lengths and widths of the parts of the body simultaneously, let us assume that the sculptor's first practical step is to record only the lengths—or heights—of the parts. For this purpose he takes a long cord exceeding the total height of the planned figure, and knots one end for his starting point (a). Taking the dimension he has determined for the length of the distal phalange of the little finger, he transfers that length to the long cord by tying a knot (b) on it at the required distance from the starting point (a). He has thus recorded the initial linear dimension of the progression, i.e., the length of the smallest phalange of the little finger (ab). On another cord, or by drawing, he constructs a square with that initial dimension as the length of its side, and takes its diagonal—both steps here involve simply the knowledge of basic geometry. The length of that diagonal represents the next length in the progression, and he records it on the long cord by a knot (c) at the required distance from the previous one. Taking this new length, (bc) he "squares" it. This diagonal represents the next length in the progression, and once more he records it by a knot (d) on the long cord. The cord now has three measurements upon it, ab, bc, and cd, which represent the lengths of the three phalanges of the little finger, from distal to proximal. The sculptor repeats the process until all the measurements along the arm are recorded on the cord (palm-wrist, forearm, upper arm).

The progression of lengths on the body proper, however, always begins from the starting point for the head length, so that (ill. 4) each new length includes the previous one as it extends from the top of the head. To produce this "overlap" effect on the long cord, the sculptor could take the last knot (g) for the arm lengths—indicating the length of the upper arm (fg) at the acromium—as his starting point for the head measurement, and proceed by recording each new dimension with that knot (g/G) as the starting point (ill. 4.).

This would enable the sculptor to place the cord directly against the figure so that the knots on the cord marking the body parts would correspond to the positions of those parts on the figure being constructed (ill. 5).



Ill. 3



Ill. 4

An alternate approach would involve the procedure of simply adding each new dimension onto the cord using as the starting point the knot that marks the limit of the previous length. This would produce a very long cord (well over twenty feet), and while it might serve as a clearer record of the separate measurements for the divisions within the body, the "overlapping cord" would obviously be preferred as a working tool during the construction of the figure:

A second cord could be used to record the widths of the body and its parts that are simultaneously determined by the progression of lengths within the system. The sculptor could have derived those widths in a procedure similar to the following:

Having determined "from nature" the ratio of length to width for the spatial number composing the distal phalange of the little finger, he constructs that rectangle with string or cord in a size that will lead to an appropriate height for the total figure

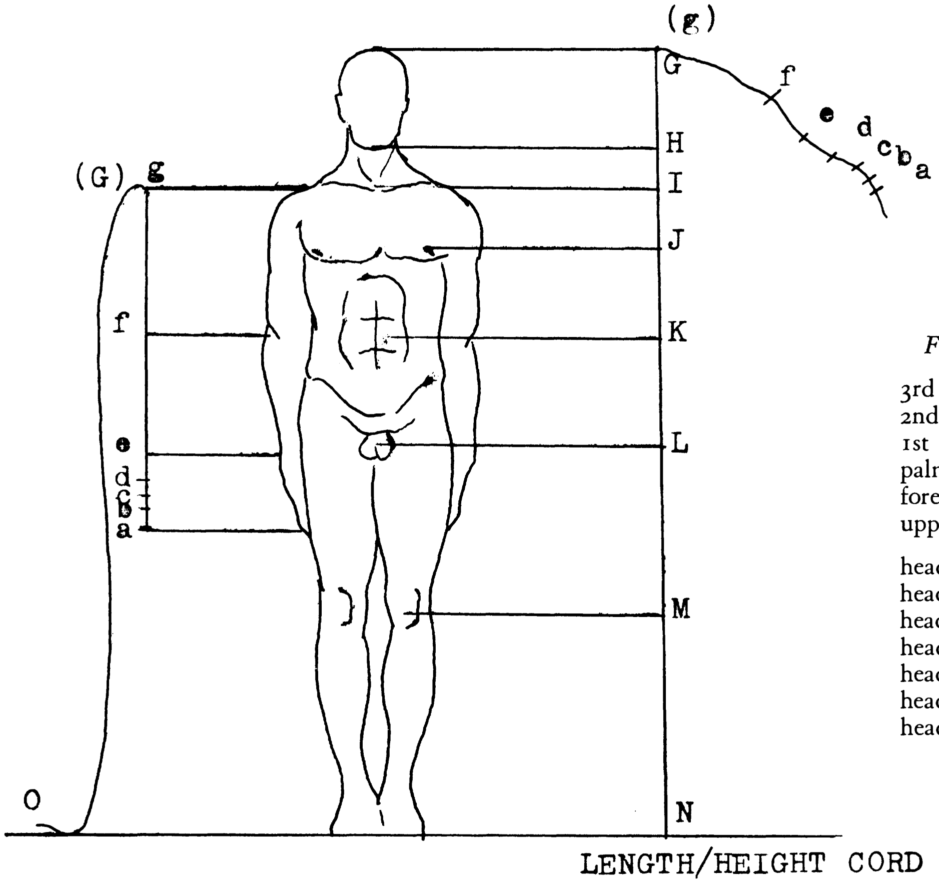


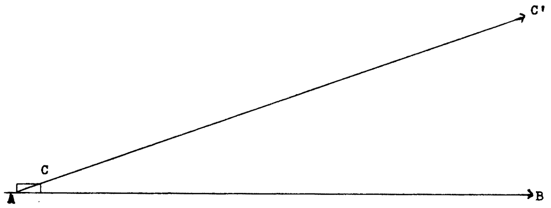
Figure	*Cord*
3rd phalange	ab
2nd phalange	bc
1st phalange	cd
palm-wrist	de
forearm	ef
upper arm	fg(fG)
head	GH(gH)
head-neck	GI
head-nipples	GK
head-abdomen	GL
head-groin	GM
head-knees	GN
head-base	GO

Ill. 5

(ill. 6). He places this rectangle on a straight line exceeding the total height of the planned figure; in effect, he extends the base line of the rectangle (ill. 6):

Ill. 6

He then takes the diagonal (AC) of the rectangle, and with the cord he extends it until it reaches a point (C^1) above the end of the base line below (AB): (ill. 7, extended diagonal AC):

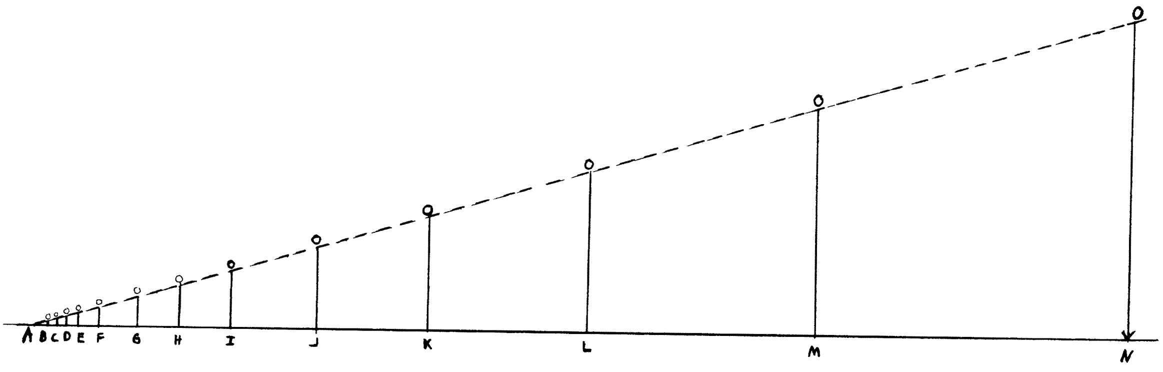


Ill. 7

Always measuring from point A, the start of the progression, the sculptor produces the series of widths by transferring the succession of lengths, recorded on the first or "length" cord (ill. 4), onto the second or "width cord" (ill. 7). The initial rectangle on the width cord represents the length and width of the distal phalange; thus the sculptor would then transfer the length of the middle phalange onto this second cord, measuring from point A as he will in all succeeding lengths. The only adjustment would involve the avoidance of a repetition of distances on the length cord: the forearm length ef—the head length GH, and the upper arm length fg(fG)—the head to clavicle length GI. To repeat them on the base line would disrupt the progression whose results depend upon the proper geometric representation. Thus the sculptor, by recording the progression of lengths from the first cord onto the second, always starting from the initial measuring point A, has expressed in practical fashion the generation of the system's module from its initial size, that of the distal phalange, to the final dimensions embodied by the height and width of the entire figure. For at each point on the base line AB that records a measure of length from the first or length cord, the corresponding width is the line dropped from the extended diagonal (AC^1) perpendicular to that point (ills. 8 and 14).

There are two steps in Polykleitos's application of his module in a geometric progression that involve his own choice as to how the system is employed. In the first instance we note that the lengths that are derived for the parts of the body along the arm—phalanges, palm and wrist, forearm, upper arm—are each applied at the point where the previous measure left off. On the body proper, however, the derived lengths are applied "internally," with the new measure always begun, not from the end of the previous one, but rather from the initial starting point on the body, at the crown of the head. Hence the system produces a proportionate division of the parts on the body proper at the same time as it relates the parts of the arm to each other through an "additive" process. On the hand itself, the three phalanges of the little finger must be taken together so that their total length can yield the palm-wrist length; and in like manner the palm-wrist is taken together with the little finger length to yield the next length, the forearm.

The second instance of the sculptor's "direction" of the system involves the transfer of the progression from the arm to the body proper; to do this



Ill. 8

he simply shifts the upper arm length over to the body, where it becomes the distance from the head to the clavicle, along the imaginary line between the acromia on the top of the shoulders. And within that head-to-clavicle length he marks the height of the head as equal to the forearm-length.

However "arbitrary" these steps might appear, it should be noted that they concern only the application of his system, not the system itself. He does not step outside of his rigid geometrical progression here. For Polykleitos, it was a question of first discovering the numerical entities which the human body concealed beneath its visible form, and then determining how those numbers worked in the whole body and all its parts. The geometric progression, working "additively" on the arm and internally on the body proper, corresponds completely to the mathematical thinking of his time as well as to the construction of the human figure in nature. In nature, the arm is indeed a part of the whole body, yet it is separate from the body proper, and its parts—upper arm, forearm, palm and wrist, and the fingers each with three distinct bones—can be regarded both visually and functionally as "parts" in a sense that does not hold in quite the same way for the "parts" on the body proper. The clavicle or neck, the chest, abdomen, groin, and knee are more accurately described as "areas" of the body rather than parts.

Hence the different ways in which the system expressed itself within the human body would not be regarded as "arbitrary" by Polykleitos and his peers. What we might consider a convenient shift from the arm to the body was for Polykleitos a response to a reality that existed in nature, both in its mathematical essence and in its visual expression. For the length of the upper arm in nature does indeed come extremely close to the distance from the crown of the head to the clavicle, on the very "line" at which the length of the upper arm is measured (i.e. at the acromium level). The height of the head itself is derived by determining the previous length, which results in a height equal to that of the forearm.

In short, Polykleitos does not violate the system through arbitrary application of it, he has simply discovered the manner in which it works within the human body.

It is equally important to stress here that the creative aspect of such an approach is complemented by, and not subjected to, the rigid requirements of geometric laws. It is the sculptor himself who determines the "ideal" form for his human figure, a form that embraces the entire body and all its parts, down to the initial shape of the phalange of the little finger. His choice of that form is an aesthetic one, and the aesthetic upon which he bases his choice is itself grounded in the current metaphysic of beauty that holds the human body, like all things in the cosmos, to be subject to and expressive of a thoroughly geometrical conception of the world. Things are numbers, or at least they contain them. Visual beauty is an expression of number. By "discovering" the number theory that corresponded to the visual proportions of the body, Polykleitos uncovered the ultimate reality of human form, and the means by which to express it. He represented men as they actually are.

There was a point however, at which Polykleitos, by his own creative judgment stepped beyond the system. This will be evident from an application of the canon to the Naples Doryphoros, a Roman replica of the Canon statue. In the interest of clarity it might be helpful first to apply the Canon to a hypothetical statue, as the "reconstruction" of the Canon on the basis of the Naples statue will become clearer after the actual construction of the system has been illustrated.

Let us assume that Polykleitos, from his study of nature, has determined that areal or spatial number which most perfectly expresses the distal phalange of the little finger. That spatial number has the ratio, expressed in metrical value, of 3.4142 to 1 (i.e., if calculated, the length of the phalange would be 3.4142 times greater than its width at the side). The sculptor has drawn or constructed that spatial number according to concrete dimensions. Let us assume that the length is set at 1.65 cm., and the width on the side is thus 0.48 cm. Taking this concrete shape as the initial embodiment of a constant module, he constructs a square on the long side and takes its diagonal, which can be calculated as 2.33 cm. He takes the cord (ill. 5) on which he has marked the length of the phalange (ab) by a knot (b), and marks the new length at c (bc = 2.33 cm.). As described above, the practical evolution of the distances along this first or "height/length" cord proceeds until the total height of the figure is recorded. The process can be expressed metrically as (Ratio 1:1.4142, ill. 5).

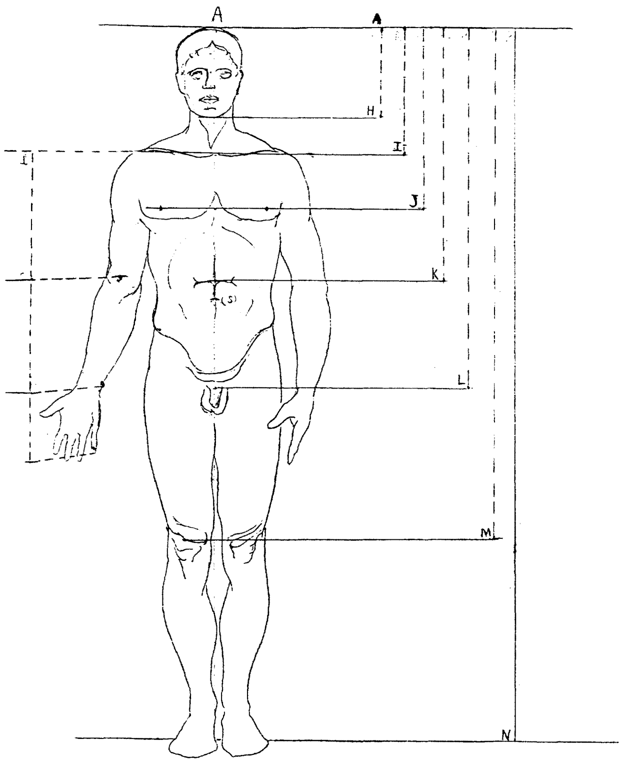
		length cord
. distal phalange:	(ab)	1.65 cm.
. middle phalange:	(bc)	2.33 cm.
. proximal phalange:	(cd)	3.3 cm.
. little finger (sum of phalanges, ad):		7.3 cm.
. palm and wrist (de):		10.3 cm.
. hand (from distal phalange to wrist at ulna, ae):		17.6 cm.
. forearm: (ef)		24.9 cm.
. upper arm (to top of shoulder at acromium, fg):		35.2 cm.
. head (forearm length — (AH))		24.9 cm.
. head to		
— clavicle (upper arm length): (AI)		35.2 cm.
— nipples: (AJ)		49.8 cm.
— abdomen: (AK)		70.5 cm.
— groin: (AL)		99.7 cm.
— knees: (AM)		141.0 cm.
— base of figure (total height): (AN)		199.5 cm.

Having marked these lengths on the first cord, the sculptor constructs the original spatial number (1.65 x 0.48 cm.) and extends its diagonal and the base line (along its long side) beyond the derived height of the figure (199.5 cm.). Always measuring from the original spatial number as the starting point, he marks off those lengths from the first cord onto the extended base line on the second cord (ill. 8). At the point where a length is marked on the base line, its corresponding width is determined as the line dropped from the extended diagonal and perpendicular to that point. Thus: (Ratio 3.4142 to 1; see ill. 8):

OB initial phalange	(1.65 to)	0.48 cm.
OC middle phalange	(2.33 to)	0.69 cm.
OD proximal phalange	(3.30 to)	0.97 cm.
OE little finger	(7.3 to)	2.14 cm.
OF palm and wrist	(10.3 to)	3.02 cm.
OG hand	(17.6 to)	5.17 cm.
OH forearm (head)	(24.9 to)	7.3 cm.
OI upper arm (head to clavicle)	(35.2 to)	10.3 cm.
OJ head to nipples	(49.87 to)	14.6 cm.
OK head to abdomen	(70.5 to)	20.6 cm.
OL head to groin	(99.7 to)	29.2 cm.
OM head to knees	(141 to)	41.3 cm.
ON head to base/ground	(199.5 to)	58.4 cm.

We thus have determined the proportions of a hypothetical figure whose "true" height—that is, its height if it were standing fully erect, feet together—comes to 199.5 cm. In the position of the Naples Doryphoros, the actual height would be reduced to approximately 196 cm., as the contraposto of the body and the slight inclination of the turning head result in a lowering of the erect figure's height by a few centimeters.

If Polykleitos had chosen to construct his Doryphoros from an initial phalange of the same dimensions as our hypothetical figure (1.65 x 0.48 cm.), the results would be identical, producing a figure of approximately 199.5 cm. (erect) and a series of dimensions for the parts identical with that of our figure, including a head of approximately 24.9 cm. in height (ill. 9).

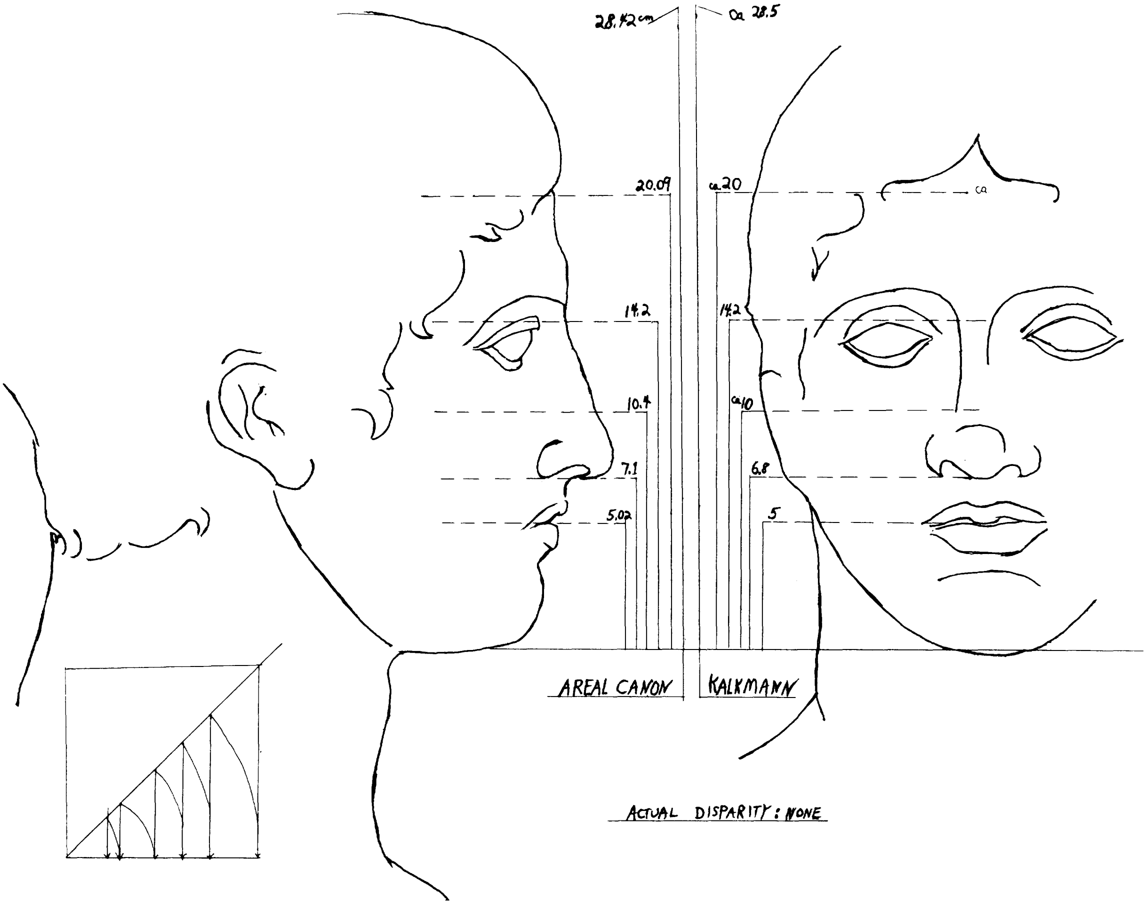


ILL. 9

It should be noted here that Polykleitos went beyond his Canon in the interest of effecting a more "ideal" form. That step, if we compare our hypothetical figure to the Naples Doryphoros, seems to have involved the enlargement of the head. If we assume this alteration has been made on the Naples copy, then the correspondence of that enlarged head-height with another measure on the figure can be used to determine what would be the height of the enlarged head of our own figure, based on a similar correspondence. The height of the Naples head is recorded as approximately 28.5 cm.; the distance between the nipples is slightly more, ca. 29 cm. On our figure the nipple distance is also ca. 29 cm.; thus the head's height, if enlarged, would come to ca. 28.5 cm., an increase of about 3.5 cm. The total height of our figure, fully erect, is now 203 cm., adding the increase to the height of the head (199.5+3.5=203). If our figure were placed in the position of the Doryphoros, with the body shifting to one side and the head slightly inclined, the actual height would be reduced to 199.5 cm. This height for our figure (199.5 cm.) thus represents the final actual height of a figure placed in the Doryphoros stance (-3.5 cm.) with the head enlarged (3.5 cm.). In other words, the loss of height through the change of position from the erect stance is cancelled out by the increase of height through the enlargement of the head. A possible allusion to this enlargement of the head on the Doryphoros can be noted in a passage of Pliny on the work of Lysippos, discussed further on.

It will be clear from our study of the Naples Doryphoros that this copy and our hypothetical figure are one and the same. In constructing our hypothetical figure we have in fact reconstructed the Naples statue according to our "Areal Canon." A study of the recorded measurements of the Naples copy will of itself confirm the validity of the areal Canon. The following is a compilation of those measurements, based on various sources and converted into metrical values where necessary:

Kalkmann[10] (Heights)	Centimeters	
Total height	199.5	AN (ill. 9)
head	28.42	AH (ill. 10)



ILL. 10

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[10] A. Kalkmann, "Die Proportionen des Gesichts in der Griechischen Kunst," *50 Berl. Winckelmannsfeste* (Berlin 1893) vol. 53, pp. 36-37.

face	19.95 PH (ill. 10)
head-to-navel	79.60 AS (ill. 9)
chin-to-midpoint	71.05 HL (ill. 9)
mid-point to navel	19.55
navel to nipples	29.7
width of shoulders:	59.4 MN
width bet. nipples	29.7 KL

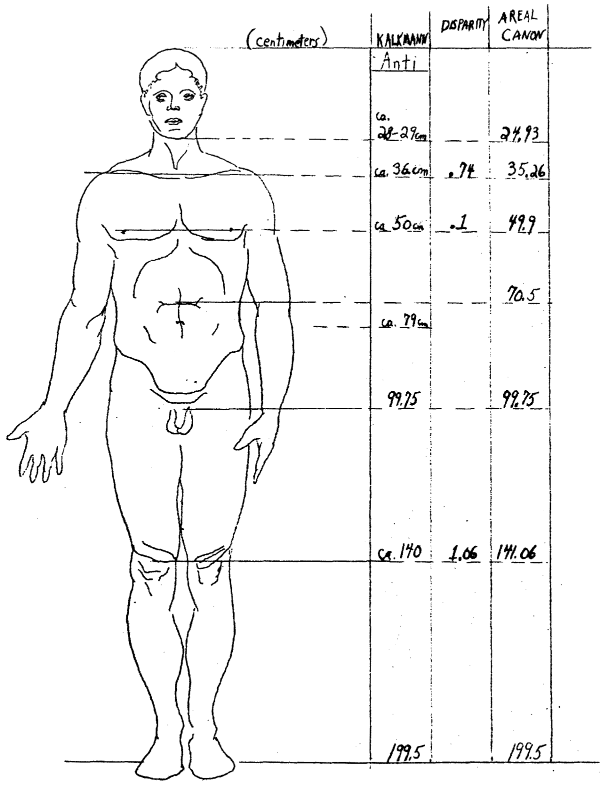
Head: (Height) Centimeters	(ill. 10)
head to neck	36.7 AI
crown to hairline	8.35 AP
crown-upper eyebrow	14.214 Ag
eyebrow to nose	7.6 qs
eye to nose	5.6
eye to mouth	7.5
eye to chin	12.437
eyebrow to chin	14.214 qh
hairline to nose	13.266 ps
hairline to mouth	14.925 pt
mouth to chin	4.975 th
eye length	3.316
length of nose	6.633
nose to chin	6.837 sh

Using his measurements:

eyebrow to eye	1.77
eye to lower lid	1.77

Anti:[11] (Centimeters) (ill. 9)

AH	height of head = distance between nipples —	ca. 29
	navel to nipples — 1 head —	ca. 29
KL	base of penis to median intersection of abdomen — 1 head —	ca. 29
	great tuberosity to internal articulation of elbow — 1 head —	ca. 29
	internal articulation of elbow to styloid process of radius — 1 head —	ca. 29
MN	base of figure (ground level) to knees (groove between patella and vastus internus muscle on support leg) — 2 heads —	ca. 58
MN	width of shoulders — 2 heads —	ca. 58



Ill. 11

Ill. 11 compares the measurements from the Naples Doryphoros with those measurements derived from our Areal Canon. There are any number of starting points for the reconstruction of the Areal Canon, including: (a) the total height of 199.5 cm.: in this instance the progression is reversed, yielding the entire series of measures for the erect figure, or for the figure placed in the Doryphoros body-position with the head enlarged; (b) any recorded measure on the Naples statue that corresponds to a part of the body measured according to the Canon; e.g. the distance between the nipples is known to be the distance between the abdomen and the mid-point or groin, the width of the shoulders is equal, in the Canon, to the distance between the knees and the base or ground level of the figure, etc. Any one of these measures, being part of the series, will yield the entire progression.

The comparison between the recorded measurements of the Naples Doryphoros and those derived from the Areal Canon indicate a metrical disparity —or margin of "error" for one side or the other— of approximately 1% (or ca. 2 cm.) for the body proper (ill. 11) and for the head, the margin is 0.9% or 9/1000 of the head height (ill. 10).

On the basis of this comparison it is valid to conclude that the Naples Doryphoros can fully support the identification of this areal system as the Canon of Polykleitos. Were only a fragment of the Naples statue to have survived, it would be possible to re-construct the entire figure from that fragment, provided it included any one of the sections of the body (on the arm, head, or body proper) considered as parts by Polykleitos, as transmitted to us through the Galen quotation. For instance, the torso would provide the nipple-distance, which is, in the Areal Canon, the distance between the abdomen and the mid-point or groin, as well as the height of the enlarged head.

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[11] Anti (supra n. 1).

The second point deals with the sculptor's starting point. Given his knowledge of Greek number theory, Polykleitos most likely conceived the system with the tip of the little finger as the starting point, as the original spatial number. At the same time, it is possible that the sculptor began with the total length-width dimensions of the entire figure, taking the body's full height and maximum width as the original spatial number. The process would then work in reverse of its evolution from the little finger: i.e. the total height is the diagonal of a square whose side is equal to the distance between the crown and the knees, etc.

The practical application of the system, though illustrated here by the use of two cords and with the little finger length as the starting point, could likewise have begun with the total height and width, and probably involved not two but one cord namely the second or "width" cord (ill. 8). For this cord, a geometrical representation of the progression yields not only the widths corresponding to the lengths (on the base line) as the verticals dropped perpendicular to those lengths, but echoes or repeats them on the base line itself: for example the distance MN between the knees and the total height is equal to the width of the total height (ON).

In other words, the distance between each point on the line and the point following it is identical with or equal to the vertical distance from the extended diagonal that is perpendicular to that following point (e.g. LM = OM, KL = OL).

If the sculptor began with the total height as the starting point, and the total height was near to or larger than life-size, he had only to work with a cord of half-scale (ca. one metre) and then double the results when recording them on the actual-size cord.

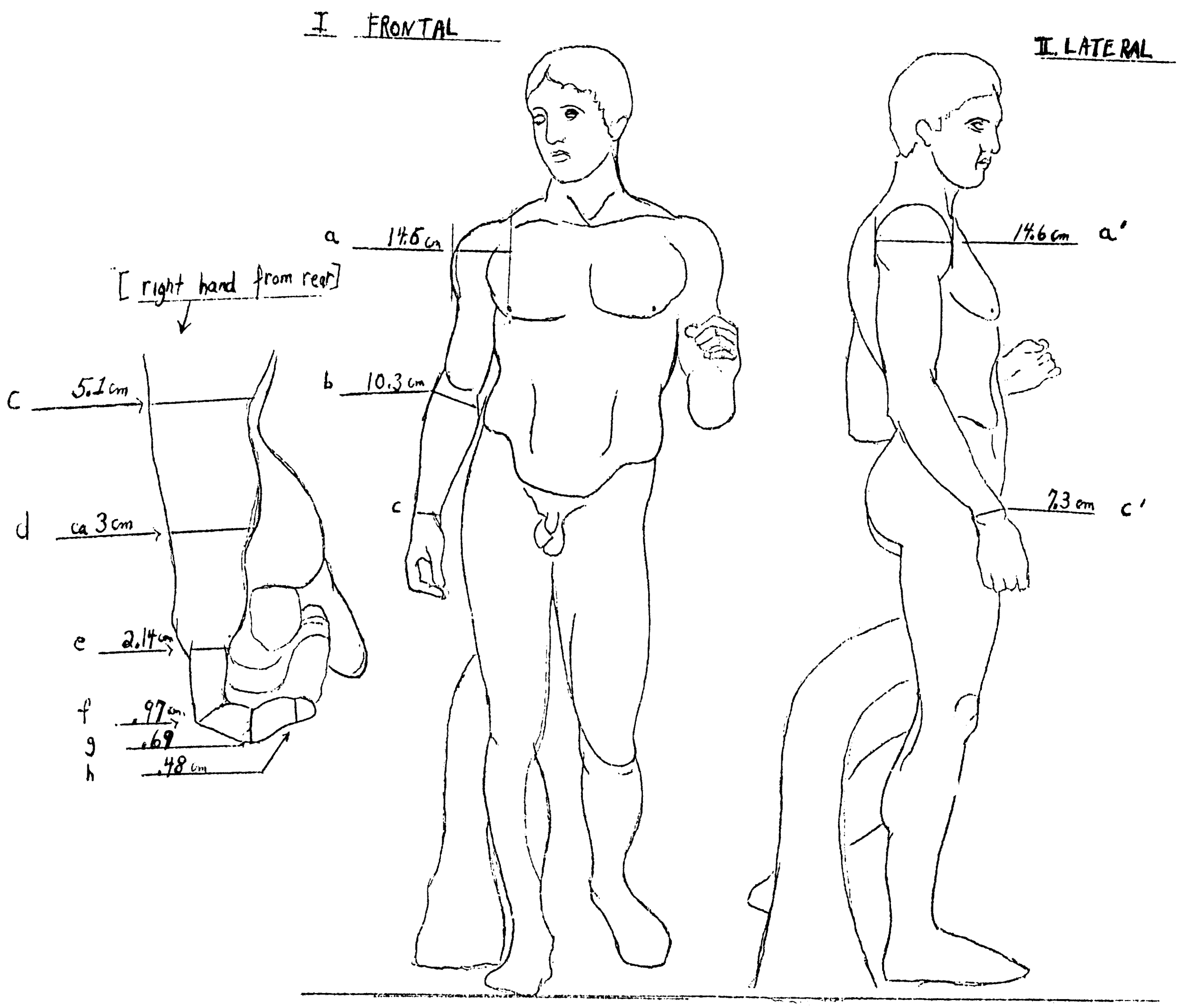
A further point should be noted here on the question of the "third" dimension, or depth. Width on the body proper, of course, refers to the span across the body taken frontally. Polykleitos's application of his widths to the arm, however, involves parts of the body where "width" and "depth" are interchangeable with the shifting frontal positions of the parts of the arm and hand. Hence the need here is to specify the positions on the arm at which the widths were measured. To my knowledge there are no complete published measurements for the widths and depths of the various parts on the arm, much less for the body proper. These would be required to determine where the widths were measured and whether the depths (the third dimension) were arrived at "canonically." It is certainly possible, and indeed likely, that Polykleitos settled the question of the depth measures "by eye" as he proceeded to construct the clay or wax model with the two-dimensional measures (length and width) supplied by his canonical system. For the proportions of the figure depend upon the dimensions of length and width; with these determined, the measurements for depth, largely uniform for the body proper and easily visualized for the parts along the arm, would simply "echo" the width, varying only slightly with them.

Practical considerations aside, the contemporary mathematical philosophy and its Pythagorean concepts of number theory were concerned with planar numbers (square, rectangle), and had not advanced their knowledge to embrace the area of stereometric shapes, or three-dimensional numbers (cube, etc.).

Our concern here then is with the width measure. The positions of the parts of the arm that yield these measures are shown in ill. 8, where the figure is shown in frontal and side view to include all the widths. The canon yields the following measures for the width along the arm, as demonstrated on the Naples Doryphoros (ill. 12).

I a: *deltoid*, frontal: from its origin on the anterior border of the last third of the clavicle, to its greatest width on the arm: 14.6 cm.
II a′: *deltoid*, lateral view: at its greatest width along the upper arm: 14.6 cm.
I b: upper arm at elbow, frontal: 10.3 cm.
II c′: forearm at wrist, lateral: 7.3 cm.
I c: hand at wrist, frontal: 5.1 cm.
I d: palm at widest point, frontal: 3 cm.
I e: little finger at base of metacarpal-phalange (proximal) joint, frontal: 2.14 cm.
I f: proximal phalange at proximal-medial joint: 0.97 cm.
I g: medial phalange at medial-distal joint: 0.69 cm.
I h: distal phalange at tip of bone (under nail): 0.48 cm.

These metrical values derived from the Areal Can-



ILL. 12

on for the Naples statue are based on the system itself rather than upon recorded measures, as these measures have not been adequately published. Were they available they would refer to restorations on the replica, i.e. the right arm and the left hand.[12] Some widths for the repaired arm are cited by Anti,[13] in terms of "finger-lengths" and palm-widths etc., but the data is insufficient to offer a complete confirmation of the above derived measures. Von Steuben's measures, while helpful, are far from complete along the arm and hand—an understandable omission in view of the author's linear approach to the system. However, the available information does indicate that the Areal Canon applies as fully here as on the head and body proper (ill. 13).

It can be noted here that while Polykleitos bases his spatial numbers on the bones of the little finger, the application of those numbers is directed to the surface dimensions of the body, and it appears that this translation from the skeletal to surface or "fleshed out" forms takes place without noticeable distortion to allow for the increase in size, in terms of the widths of the parts. Such an adjustment would not be necessary with regard to length, as the parts of the body used in the system—finger and arm bones, head and clavicle, etc.—are largely unaffected by the addition of the flesh of the living form. In other words, they do not vary in their

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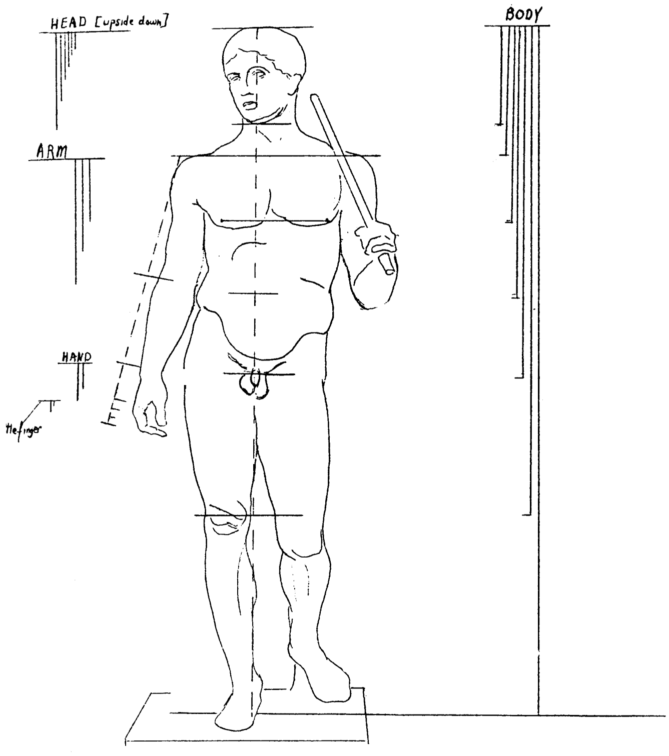
[12] Arias (supra n. 1) 139, nos. 30-33.

[13] Anti (supra n. 1).



Ill. 13

positions from one another with regard to length. As to the effect of living flesh on the widths of the parts, the only real adjustments would involve the tip of the little finger, in which the nail and flesh extend beyond the end of the first bone. Most of the widths are taken at the juncture of one bone with another, at which point the bone is physically and visibly evident just beneath the thin sheathing of flesh. It does appear that Polykleitos applies the shoulder width to include the increase at the deltoids, and the elbow width to include the muscles at the elbow, thus in effect employing a width at the surface. Once again this is a question of the application of his system. It is not inconsistent for the sculptor to use one resulting width for the bone and another for the bone sheathed with flesh. For he could find justification for such application in the proportions of the human body in nature. And the fact that the parts of the skeleton were covered yet not really concealed in the appearance of the living form would be quite consistent with a "mentalità pitagorica" which held the numerical essence of things to be hidden beneath their physical reality. Yet aside from this philosophical context, the "addition" of living flesh to the spatial numbers of the skeletal parts of the body in no way distorts their forms or disturbs their progression. In some instances it actually serves to realize their full application to the body.

THE ANCIENT SOURCES[14]

The practical solution proposed here can be evaluated on its own merits, yet a case can be made for it by its correspondence with a consistent interpretation of the body of ancient sources on the Canon.

Δάκτυλος in Galen's description of the Canon can be understood to be the distal phalange of the little finger, i.e. the generating module. The "squaring" of that module in the geometric progression of the diagonal produces a chain of commensurable parts in exact correspondence to the ordering of parts in the Galen passage. This system of commensurability is further reinforced by the fact that it is a true reflection of current Greek number theory and geometric practice.

If we understand the Philon fragment to read: "Beauty, he said, was produced (γίνεται) from a small unit (παρὰ μικρὸν) through a long chain of numbers (διὰ πολλῶν ἀριθμῶν),"[15] then the μικρὸν can be identified as our initial unit[16]—the spatial number that makes up the length-width of the distal phalange. This spatial unit generates a chain or series of related spatial numbers (πολλῶν ἀριθμῶν) through its geometric progression. That same initial module can be related to what Plutarch calls καιρός, the "due measure" that guides the many numbers that evolve toward the beautiful.[17]

In Pliny's remarks on the *Canon*, the reference to the squarely-built (*quadrata*) figures of Polykleitos, made again in his discussion of Lysippos, can be understood—whatever Pliny's own view of

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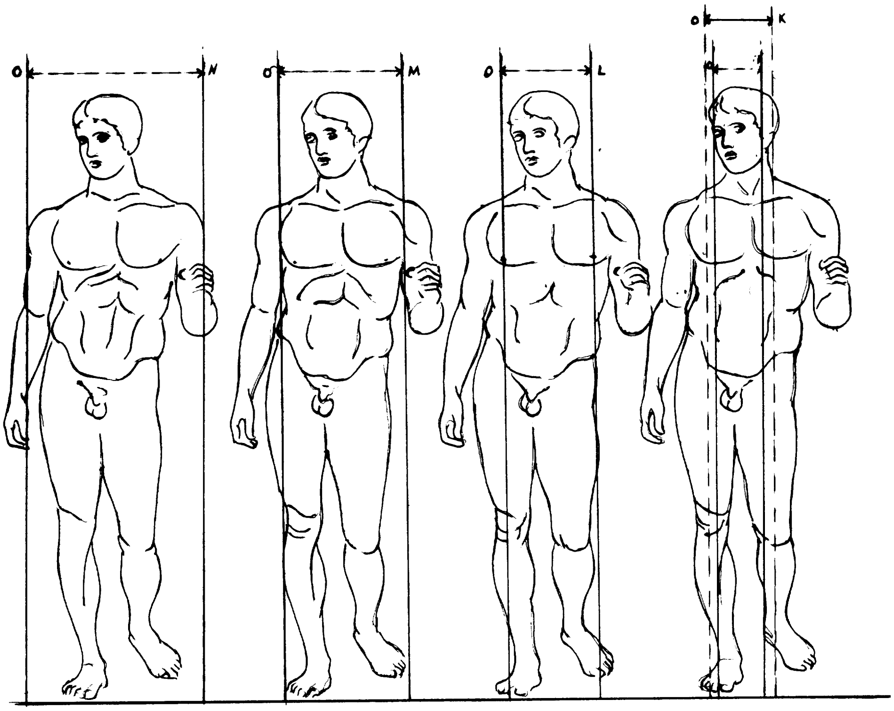
[14] For a compilation of ancient sources on Polykleitos and the Canon see Bianchi Bandinelli (Greek texts) and Arias (Italian translations), supra n. 1.

[15] Translation by H. Stuart-Jones, *Ancient Writers on Greek Sculpture* (Oxford 1895), 129. H. Diels, *Die Fragmente der Vorsokratiker*, "Polykleitos," 40 B. no. 2, line 5, ed. Kranz (Berlin 1956) [Vol. 1, 393].

[16] "μικρὸν" here seems to indicate a small unit in general, as Philon's statement on beauty—though applied in this case to mechanics—appears to be an allusion to the Polykleitan process in the abstract. While the interpretation of παρὰ μικρὸν in Philon is open to dispute, the present inquiry suggests that the initial unit for Polykleitos was the little finger, which incidentally is rendered as μικρον in at least one reference to it in Galen's περὶ χρείς μορίων.

[17] Plutarch, *Moralia* (περὶ τοῦ ἀκούειν) 45 C-D.



Ill. 14

the term—as the "squaring" process of each spatial number in the geometric progression.[18] In other words, the squareness of the Polykleitan figures refers primarily to the mathematical procedure at the core of their construction: each succeeding length becomes the side of a square, the diagonal of which produces the next length in the progression. The effect of this manner of construction is apparent in the physical appearance of a statue built along these lines: athletic, powerful, "squarely built." At some point in the transmission of information on the Canon the technical meaning of the "squareness" was lost, and replaced by the allusion to the visual appearance of his figures. It is in this limited meaning that the "quadrata" of the Polykleitan system reached Pliny.

In the light of the present theory, another ancient source for the work of Polykleitos may assume a special significance here. In *Quaest. Conu.* II.3.2. Plutarch writes: "Polykleitos the sculptor said that the work was most difficult when the clay came under the nail (ἐν ὄνυχι ὁ πηλὸς γίνηται)."[19] The apparent meaning would be that the sculptor's creative efforts were most critical at the end of the process of execution, where the concern would be with the proper surface finish. Yet this reading passes over the problems of proportion, which we know were of central import for the author of the Canon. If we understand the practical system of that Canon to be the result of the generation of the spatial unit of the distal phalange in a geometric progression, it is perhaps clearer to see why the work was so difficult "when the clay is on the nail." I would suggest that this refers not to the point of completion, but rather to the starting point for the proportional structuring of the entire figure: i.e. the nail, the point where the distal phalange begins. Hence the difficulty referred to here is not one of surface finish but of *symmetria* itself: establishing the proportion that will inform the entire framework of the figure still to be constructed.

We stated in our investigation of the Roman copies of the Doryphoros that an intentional alteration by the sculptor did occur within his system. The creative demands for the figure as he conceived it required that he enlarge the head better to conform to his own plastic conception of the ideal form that the Doryphoros was meant to embody. If this is the case, one can more easily concur with Ferri's observations[20] on the section in Pliny on the work of Lysippos: Pliny noted how the fourth century sculptor "made the head smaller and the body more slender and firmly knit than earlier sculptors, thus imparting to his figures an appearance of greater height."[21] The "earlier sculptors" would obviously refer in the first place to Polykleitos, whose Canon-statue Lysippos claimed for his model. This is made more evident further on: "There is no name in Latin for the canon of proportions (*nomen symmetria*)[22] which he (Lysippos) carefully observed, exchanging the squarely-built statues (*quadratas . . . staturas*) of the older artists for a new and untried system (*nova intactaque ratione*)—or more literally, "by means of a new and untried *ratio*."

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[18] Pliny, *NH* XXXIV 55, translation by Stuart-Jones (supra n. 15): ". . . squarely built and seem almost to be made on a uniform pattern."

[19] Translation by Stuart-Jones (supra n. 15).

Ferri underlines the implications of this text: First, Lysippos took a new approach to the old Polykleitan "squarely-built" system, yet he by no means abolished it; in fact, he carefully preserved it (*diligentissime custodivit*). Secondly, working within the Polykleitan Canon, he effected changes by 1.) making the head smaller, and 2.) making the body more slender, to agree with the head and suggest a greater height. It is probable that what he abandoned was the ratio of the *diagonal*, thus replacing the "squarely-built" figure, and obtained a more narrow figure through the use of his *nova intactaque ratione*.

Pliny continues: "He (Lysippos) was in the habit of saying that they (the older artists) had represented men as they were (*quales essent homines*) while he represented them as they appeared to the eye (*a se quales viderentur esse*)."[23] It is not difficult to concur with Ferri's suggestion that these phrases point up the passage from a geometric (Polykleitan) to an optical (Lysippan) symmetry, developed during the fourth century in reaction to the rigid mathematical symmetry of the Canon.[24] This raises the whole question of the Greek concept of "nature," with its paradoxical process of arriving at an incredibly faithful representation of nature as seen by the eye, through so abstract a method as that of mathematical theory. For if the "real" in nature, to the Pythagoreans and later to Plato,[25] lay in the geometric or mathematical forms not visible to the eye, then Polykleitos's formulation of his Canon upon mathematical principles truly depicted men *quales essent*, as they actually are, beyond mere visual appearance.

Lysippos claimed to be more concerned with men *quales viderentur esse*, in their visual or psychological state, though such a radical departure from the "mathematical" concept of nature (a departure that Plato criticized precisely because it only showed men as they appeared to visual perception)[26] was largely tempered by his continued adherence to the Polykleitan geometric structure.

This question of "truth-to-nature" occurs as late as the early Renaissance, so that while Alberti speaks of the new perspective as being true to nature, he really means nature as grounded in mathematical principles. Thus the question of "live model" versus the pattern-book is subordinate to the larger dualism of nature as seen directly by the eye vis-à-vis nature as revealed through mathematical law. Nature for Leonardo could not be conceived without reference to both.

The system of proportion perfected in the *Doryphoros* was built upon the most basic elements of Pythagorean geometry, and within the Greek mathematical tradition.[27] The Canon of Polykleitos may represent the first known instance in Greek sculpture of an artist's successful attempt to create a rare and elusive balance between the laws of nature and the demands of his craft:

"artem ipsam fecisse artis opere . . ."

BRYN MAWR COLLEGE

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[20] Ferri (supra n. 1).

[21] Pliny, *NH* XXXIV 61, translation by Stuart-Jones (supra n. 15), 196, no. 241.

[22] I suggest that by the time of Pliny the original understanding of symmetry was preserved in the Latin *concordia*, for the Greek *ἀρμονία*. *῾Αρμονία*, and hence *concordia*, was simply an equivalent concept for symmetry considered on the aesthetic level. In other words, *συμμετρία* was the mathematical, technical or artistic term for the state of commensurability among the parts and the whole, while *ἀρμονία*, a term with no direct mathematical reference, expresses the same notion from a broadly philosophical or "aesthetic" viewpoint. It is much the same to speak of the object of symmetry as "the right effect," and the object of harmony as "beauty" or "the beautiful."

[23] Translation by Stuart-Jones (supra n. 15) 197, no. 241.

[24] See also Schulz (supra n. 1) 208ff.

[25] See A.E. Taylor, Plato: *The Man and His Work* (New York 1956).

[26] Plato: *Sophist*, 234-36.

[27] I suggest that the effects of this "mentalità pitagorica" (Anti, supra n. 1) upon Greek art were felt long before the appearance of the Canon in sculpture; namely, in the area of architecture. In the first of a three-part study on Greek proportion (of which this article on the Canon is an abridgment of Part II), I sought to establish the presence of a similar spatial system for a number of Greek temples. I suggested further that the Canon might have been directly stimulated by the employment of such a system for the Periclean Parthenon.

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